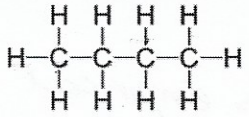
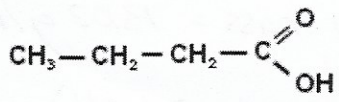
Chemistry 11

Empirical Formula & Percent Composition

Name: Key
Date:
Block:

1. Complete the following table:

Structural Formula	Molecular Formula	Empirical Formula
	C_4H_{10}	C_2H_5
	$C_4H_8O_2$	C_2H_4O

2. A pigment on a suspected forgery is analyzed using X-ray fluorescence and found to contain 0.5068 mol Ba, 0.5075 mol C, and 1.520 mol O. Determine its empirical formula.

$$\frac{1.520\ mol\ O}{0.5068\ mol\ Ba} = 2.999 \sim 3$$

$$\frac{0.5075\ mol\ C}{0.5068\ mol\ Ba} = 1.001 \sim 1$$

$\boxed{BaCO_3}$

3. A sample of caffeine is analyzed and found to contain 1.4844g C, 0.1545 g H, 0.4947g O and 0.8661g N. Determine the empirical formula of caffeine.

C: $1.4844\ g \times \frac{1\ mol}{12.01\ g} = 0.1236\ mol\ C$

H: $0.1545\ g \times \frac{1\ mol}{1.01\ g} = 0.1530\ mol\ H$

O: $0.4947\ g \times \frac{1\ mol}{16.00\ g} = 0.03092\ mol\ O$

N: $0.8661\ g \times \frac{1\ mol}{14.01\ g} = 0.06182\ mol\ N$

$$\frac{0.1236\ mol\ C}{0.03092\ mol\ O} = 3.997 \sim 4$$

$$\frac{0.1530\ mol\ H}{0.03092\ mol\ O} = 4.948 \sim 5$$

$$\frac{0.06182\ mol\ N}{0.03092\ mol\ O} = 1.999 \sim 2$$

$\boxed{C_4H_5N_2O}$

4. A sample of ascorbic acid, also known as vitamin C, was analyzed and found to contain 1.080g C, 0.121g H, and 1.439g O. Ascorbic acid has a molar mass of 176.1g/mol. Determine the molecular formula of ascorbic acid.

C: $1.080\ g \times \frac{1\ mol}{12.01\ g} = 0.08993\ mol\ C$

H: $0.121\ g \times \frac{1\ mol}{1.01\ g} = 0.120\ mol\ H$

O: $1.439\ g \times \frac{1\ mol}{16.00\ g} = 0.08994\ mol\ O$

$$\frac{0.120\ mol\ H}{0.08993\ mol\ C} = 1.33 \times 3 = 4$$

$$\frac{0.08994\ mol\ O}{0.08993\ mol\ C} = 1.000 \times 3 = 3$$

$C_3H_4O_3 \Rightarrow$ molar mass: $88.07\ g/mol$

$$\frac{176.1\ g/mol}{88.07\ g/mol} = 2$$

$2(C_3H_4O_3) \Rightarrow \boxed{C_6H_8O_6}$ ← molecular formula

5. A hydrocarbon is a compound containing only carbon and hydrogen. One particular hydrocarbon is 92.29% carbon by mass. If the compound's molar mass is 39.0g/mol then what is its molecular formula?

$100.00 - 92.29g = 7.71g\ H$

C: $92.29g \times \frac{1mol}{12.01g} = 7.684mol\ C$

H: $7.71g \times \frac{1mol}{1.01g} = 7.63mol\ H$

$\frac{7.684}{7.63} = 1.01 \sim 1$

∴ CH is empirical formula

molar mass = 13.02 g/mol

$\frac{39.0g/mol}{13.02g/mol} = 3.00$ $\quad 3(CH)$ molecular formula

$\Rightarrow \boxed{C_3H_3}$

6. Find the percent composition by mass of the following compounds:
   a. Carbon dioxide CO_2

$(12.01) + (16.00 \times 2) = 44.01g/mol$

$\frac{12.01}{44.01} = 27.30\%\ C$ $\quad \frac{12 \times 16.00}{44.01} = 72.71\%\ O$

   b. K_2CO_3

$(2 + 39.10) + (12.01) + (3 \times 16.00) = 138.21g/mol$

$\frac{(2 \times 39.10)}{138.21} = 56.58\%\ K$ $\quad \frac{12.01}{138.21} = 8.690\%\ C$ $\quad \frac{3 \times 16.00}{138.21} = 34.73\%\ O$

   c. Ammonium phosphate $(NH_4)_3PO_4$

$(3 \times 14.01) + (12 \times 1.01) + (30.97) + (4 \times 16.00) = 149.12g/mol$

$\frac{(3 \times 14.01)}{149.12} = 28.19\%\ N$ $\quad \frac{12 \times 1.01}{149.12} = 8.13\%\ H$ $\quad \frac{30.97}{149.12} = 20.77\%\ P$ $\quad \frac{4 \times 16.00}{149.12} = 42.92\%\ O$

   d. C_8H_{18}

$(8 \times 12.01) + (18 \times 1.01) = 114.26g/mol$

$\frac{8 \times 12.01}{114.26} = 84.09\%\ C$ $\quad \frac{18 \times 1.01}{114.26} = 15.91\%\ H$

   e. $C_4H_{10}O$

$(4 \times 12.01) + (10 \times 1.01) + (16.00) = 74.14g/mol$

$\frac{4 \times 12.01}{74.14} = 64.80\%\ C$ $\quad \frac{10 \times 1.01}{74.14} = 13.62\%\ H$ $\quad \frac{16.00}{74.14} = 21.58\%\ O$

1. C_4H_{10}, C_2H_5, $C_4H_8O_2$ 2. $BaCO_3$ 3. $C_4H_5N_2O$ 4. $C_6H_8O_6$ 5. C_3H_3 6a. 27.30% C, 72.71% O b. 56.58% K, 8.690% C, 34.73% O c. 28.19% N, 8.13% H, 20.77% P, 42.92% O d. 84.09% C, 15.91% H e. 64.80% C, 13.62% H, 21.58% O